

Interactive comment on “Variability in stream discharge and temperatures during ecologically sensitive time periods: a preliminary assessment of the implications for Atlantic salmon” by D. Tetzlaff et al.

Anonymous Referee #1

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The aim of the manuscript is to improve the comprehension of the effects of the variability in stream discharge and water temperature on Atlantic salmon (*Salmo salar* L.) used as study species. The authors state that this comprehension is needed to obtain ecologically acceptable flow regimes in order to meet the criteria of the Habitat Directive and the EU Water Framework Directive. The main arguments of the manuscript are that (1) that subhourly data of stream discharge and hourly data of water temperature would provide a better approach to characterize the variability in flow and thermal conditions than using mean values on daily, monthly, or annual basis, and (2) that focusing the analyses of the effects of variability in flow and thermal conditions on “ecologically sensitive time periods” would present a biologically more meaningful attempt.

General comments

1. The paper needs to be rewritten and restructured in many aspects. The authors may use scientific terms with more precision. There is a striking lack of correspondence between the objectives announced and the results presented. In opposite to my expectation, after having read Abstract and Introduction, the MS does not provide a comparative analysis of stream discharge and water temperature data on different temporal scales (subhourly, hourly, daily, monthly, and annual). The results are very descriptive, missing statistical evidence for the authors' strong statements. It would be helpful if the authors would provide numbers, factors or percentages to describe and discuss their findings instead of using relative terms like higher, lower (see specific comments). The reader is often left alone with the interpretation of the results and in the discussion of the results.

2. The largest part of the results describes the inter- and intra-annual variation of discharge and temperature of a small Scottish stream (Girnock Burn) concluding that marked variability occur in both variables. However, these facts seemed to be already well understood p.696, 19 "The stream is characterized by high variability in discharge dynamics and thermal regimes (Moir et al. 1998; Malcolm et al. 2002; Soulsby et al. 2005b)" which leads to the question if the analyses of 10 year data presented in the MS leads to any new findings regarding the variability in flow and thermal conditions.

3. The authors define four "ecologically sensitive time periods" in the Atlantic salmon life cycle. I am surprised by their choices as in general the over wintering of the fertilized eggs in the substrate, over wintering of juveniles (corresponds to Period 2 of MS), sea migration of smolts and sea survival of adults are seen as the critical life stages for Atlantic salmon survival. At the outset, I was wondering if these fixed time periods are relevant to Atlantic salmon inter-annual behavior or if the behavioral variations are more likely to be related to variations in hydrological and thermal conditions. In other words, are Atlantic salmon consulting a calendar when to migrate to the spawning grounds or is migration more likely related to the hydrological and thermal variables and should

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therefore be adjusted to annual variation of these variables. Please address.

4. The use of the critical displacement velocity (CDV) as variable to assess the effects of discharge and temperature variation on juvenile Atlantic salmon is not mentioned in Abstract and Introduction. My principal concern regarding this manuscript lies in the comparison of mean flow velocity estimates at 0.6 of water depth obtained from one point in the catchment to CDVs. I believe that the mean flow velocity at the downstream end of Girnock Burn, obtained from discharge data of a gauging station has strictly nothing to do with the “bottom” or “nose” flow velocity experienced by the juvenile Atlantic salmon throughout the river system. In their microhabitat, juvenile Atlantic salmon use spatial flow variations to reduce their energetic costs of swimming and profit from the interstice between boulders to seek shelter from critical flow velocities. Furthermore, even if bottom flow velocities throughout the catchment would be available, it rests questionable what the flume derived CDV means in a natural flow environment. In conclusion, I am not convinced that the comparison of the mean velocity and CDVs is valid.

5. Concerning the effect of stream discharge on the upriver migration of adult Atlantic salmon, I do not understand why the authors analyze the effect over the entire hydrological year on the number of return salmon in the first place. When focusing on the relevant time period, the authors state that there is a strong correlation between number of female returns and the coefficient of variation of discharge. However, the relation seems to be strongly affected by the outlier of 1995/96. The authors do not provide any interpretation of how adult female salmon may detect variations in the coefficient of variation of discharge. Furthermore, the announced coincidence between number of Atlantic salmon return and stream discharge (Fig. 10) is lacking statistical analyses to obtain an objective estimate if stream discharge and number of Atlantic salmon return are effectively related.

Specific comments

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Title: Delete plural “s” on temperatures.

Abstract: p.692, 6 and throughout the text: Are hydrological and hydraulic used as synonyms? Please precise that the measurement frequency for discharge was 15 min and for water temperature 60 min. Keep the same order of the two variables throughout the text e.g. first discharge, second temperature or vice versa but consistent. p.692, 13 Please provide readers with the results of the MS rather than with general statements. p.692, 15 For Atlantic salmon, we generally speak about spawning grounds rather than breeding areas. p.692, 18 The MS tries to link the variability of hydrological and thermal conditions to CDV of juvenile and upriver migration of adult Atlantic salmon. It does not elucidate any link between discharge and temperature variability and salmon habitat availability and utilization. Please correct.

Introduction: p.692, 25 Stream discharge and water temperature are driving what and on which scales? Please precise. p. 694, 4 “This is not the case.” Please explain your statement, would need some reference. p. 694, 24 Why are the Scottish rivers “internationally” important as habitat for Atlantic salmon? p. 695, 28 Please adjust the objectives to the results actually provided. p.696, 4 Delete last two sentences.

Study site p.696, 10 Give reference (Fig.1) on the end of the sentence. Delete reference to (Fig. 1) in the second sentence. p.696, 17 Delete sentence.

Data and methods Hydrological and hydraulic data I am still a bit puzzled about the use of hydrological and hydraulic, if there are used as synonyms than use only one term. p.698, 4 Delete sentence, no relevance for present MS. p.698, 5 Why are velocity time series hydraulically meaningful? What is meant with velocity time series were constructed? p.698, 18 Please precise this statement, low and high relative to what?

Change the title to Stream temperature data p. 698, 21 At how many locations stream temperature were measured? “Data capture was approximately 93%.” Does this mean that 7% of the data was filled in with the explained method using a relation between water and air temperature? Please address the potential bias of the analyses by using

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monthly data to fill the missing data gaps.

Biological data p.699, 15 Discuss the potential of benthic feeding of juvenile Atlantic salmon as food opportunity during increased flow velocities. Also, flood events may increase the amount of drift in the water column which may actually result in a higher food supply for juvenile Atlantic salmon. p. 699, 25 Please provide data and relation on the daily growth estimates of juvenile Atlantic salmon. p. 700, 10 Concentrate on the time period relevant for the study.

Results Characterization of stream discharge p.700, 21 First sentence could be deleted. p.701, 15 Please provide your interpretation why the coefficient of variation calculated as ratio between mean and standard deviation should have an effect on the upriver migration of adult Atlantic salmon. Are the mean and the standard deviation calculated over the entire ecological sensitive time period or is a finer resolution used? p.701, 21 “99% in period 4 and 78% in period 3” - Percentage of what from what? The paragraph is very enumerative without needing to be. Combine into fewer, more concise sentences.

Characterization of water temperature (delete plural s) 702, 20 Cumulative stream temperatures were not mentioned before in Material & Methods.

Effects on foraging behavior of juvenile Atlantic salmon (add Atlantic) p. 703, 4 Why is this not done for 2+ fish? No statistical evidence provided.

Effects on returning spawners p.704, 8 First paragraph could be deleted without any information lost. p.704, 15 I do not see the strong correlations between number of female returns and the coefficient of variation of discharge and maximum discharge (Fig. 9). Both relations seem to be strongly driven by the outlier point of 1995/96. p values of the relations should be provided. p.704, 24 The authors should prove the announced coincidence between number of Atlantic salmon return and stream discharge with some statistical analyses to obtain an objective estimate if the number of Atlantic salmon return and stream discharge are correlated.

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Discussion: First paragraph provides a general discussion without any focus on the findings of the MS. Link discussion to the findings of the present MS. p.705, 9 What is meant with directly and indirectly? Please explain. p.706, 29 Please precise, what is meant with much more evenly distributed? p.707, 7 How does the predation risk for adult Atlantic salmon in streams relate to the predation risk at sea? p.707, 15 Weak or no interpretation of the effect of the coefficient of variation of discharge on the upstream migration of female Atlantic salmon. What is meant with “Numerically, full juvenile recruitment to stream populations”? p.707, 21 Replace breeding by spawning. p. 707, 23 The MS failed to demonstrate evidence that high resolution data on stream discharge and water temperature provide more insights than average data. In addition, the authors do not provide any comparison which of the used hydrological variables (mean, min, max, CV discharge and mean flow velocity) is more meaningful. The “ecologically sensitive time periods” were not validated.

Tables: Table 1 and 2 may be combined. I don't think that minimum and maximum discharge values can be called parameter.

Table 3 Why is data for 2+ fish not given? Table 4 Provide p values for the relations. Is there a significant relation between standard deviation of discharge and number of returns?

Figures: In general, figure captions should be more elaborated. Figure 1: Provide latitude and longitude in overview map.

Figure 2: Add unity of discharge to figure caption and legend. I am surprised by the relative low mean flow velocities. Do I understand right that even at highest observed discharge, mean flow velocity never succeeds more than 75 cm \overline{T} s-1?

Figure 3: What does “used within the study” mean? Were there adults returning that were not used in the study?

Figure 4: What kind of scale has the x-axis used in this figure? Why does the distance

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become large between 70% and 90% than between 50% and 70% time exceeded?

Figure 5: How is cumulative discharge (mm) supposed to affect juvenile Atlantic salmon? Why is accumulation started on October 1st?

Figure 6: Why is upper temperature limit not given and why is the lower temperature limit after Elliot and Hurley (2003) given, if Bacon et al. (2005) found that wild fish grow below this temperature (p.702, 12)?

Figure 8: Difficult to see anything. Perhaps it would be useful to display CDV on a second y-axis using another scale in order to provide some clarity. Why are fry and 2+ fish data not given?

Figure 9: Provide statistics.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 691, 2005.

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